Spectral and Power Stability Tests of Deep UV LEDs for AC Charge Management

UV LED lifetime > 1,000 hours

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Motivations & Objectives

•Electrical charges may accumulate on the GRS proof mass due to ionization by deep space cosmic rays, electron migration via cold cathode emissions, and work function differences during proof mass and caging separation.

•Need to remove these charges from the proof mass.

•Evaluate the suitability of UV LEDs as a flight light source for long-term charge management.

•Charge management system
- -UV light transport using specialty fibers --- lifetime, stability over the projected LISA lifetime of 10 years. Stanford has been running UV fiber aging tests since GP-B and now for the STEP project. Support for LISA work will enable access to this valuable data.
- -UV charge management with different surfaces and coatings.
- -UV delivery geometry studies.

•UV LED based charge management
- -An evaluation of the implementation of a UV LED source in flight hardware
- -Evaluation of LISA Pathfinder as a means of testing UV LED and advanced charge management techniques, such as AC charge management

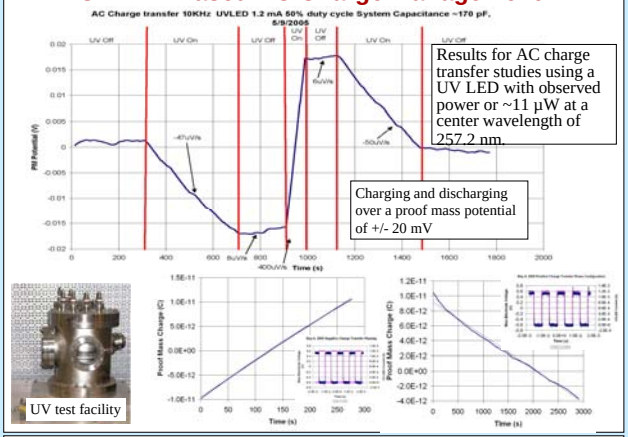
UV LED vs. Mercury Lamp

UV LED
- Light weight
- Less power consumption
- Compact size

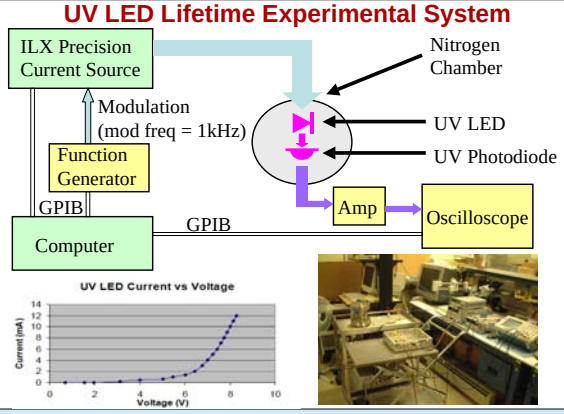
GP-B CMS in Flight
- 2 Hg Lamps
- Weight: 3.5 kg
- Electrical Power 7~12 W

Category	*UV LED CMS*	*RF Mercury Lamp CMS*
Electrical Power Consumption	1 W	15 W
EMI	Minimal	Large due to RF excitation
Weight	0.3 kg	3.5 kg
Dimension of the CMS system	10 cm x 8 cm x 3 cm	17 cm x 13 cm x 17 cm
UV emission power	~120 μW	~100 μW
UV Power at the fiber tip	~16 μW	~11 μW
UV Wavelength, central	257 nm	194 nm & 254 nm
UV Wavelength, spread	12.5 nm	Doppler Broadening
Fast modulation capability	Yes – Intensity, pulse train frequency and phase, etc.	No
Charge management method	AC & DC	DC only
Charge management frequency	Out-of signal band	In signal band
Equivalent dynamic range	100,000	100
Charge management resolution	high	low
Charge management speed	high	low

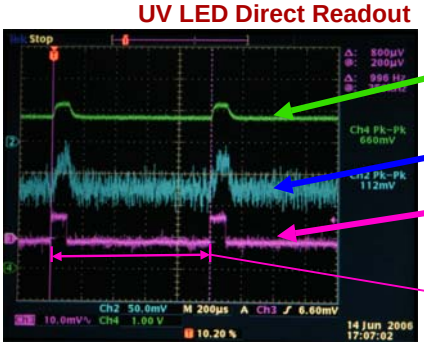
UV LED Based AC Charge Management



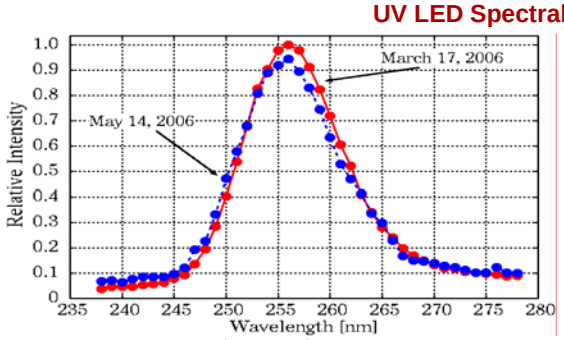
UV LED Lifetime Experimental System



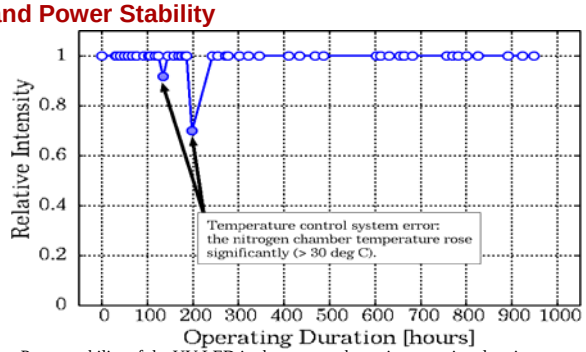
UV LED Direct Readout



UV LED Spectral and Power Stability



•UV LED emission spectrum before (red), after 250-hour operations (blue).
•No major spectral shift is observed.
•UV LED is highly expected to last for significantly longer than 1,000 hours.



•Power stability of the UV LED is shown over the entire operating duration.

•Power level has stayed relatively constant, as observed using a UV photodiode.

Concluding Remarks

•Deep UV LED is a promising light source for charge management of high precisions missions: LISA, BBO, ST7, STEP ….

•UV LED lifetime is more than 1,000 hours as of July 16th.

•Further development on UV LED based charge management system for LISA is a must.

References

[1] K. Sun, B. Allard, S. Williams, S. Buchman, and R. L. Byer, "LED Deep UV Source for Charge Management," presented at Amaldi 6 Conferences on Gravitational Waves, June 2005, *Classical and Quantum Gravity*, 23(8):S141-S150, 2006.

[2] K. Sun, B. Allard, S. Williams, S. Buchman, and R. L. Byer, "LED Deep UV Source for Charge Management for Gravitational Reference Sensors," *Class. Quantum Grav.* 23 (2006) S141-S150

[3] Ke-Xun Sun, Sei Higuchi, Brett Allard, Dale Gill, Saps Buchman, and Robert Byer, "LIGO Test Mass Charging Mitigation Using Modulated LED Deep UV Light, " LIGO Science Collaboration (LSC), OWG & SWG Joint Meeting, Hanford, Washington, March 22, 2006, LIGO Documentation G050143-00-Z